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REPORT NO. RR-TR-63-17

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ATMOSPHERIC ENVIRONMENT FOR PERSHING MISSILE 405

12 June 1963

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ATMOSPHERIC ENVIRONMENT FOR PERSHING MISSILE 405

by
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Redstone Arsenal, Alabama

ABSTRACT

This report presents the atmospheric environment for the flight of PERSHING Missile-405, which was launched on 4 March 1963, at 2000 EST, from the Atlantic Missile Range, Cape Canaveral, Florida. The general synoptic situation for the flight area, surface observations at launch time, and upper air conditions as measured by rawinsondes released as close to missile launch time as possible are given. High altitude wind data over the launch area as determined from a meteorological rocket flight are also presented.

Relative deviations of thermodynamic quantities from the Patrick Air Force Base Annual Reference Atmosphere are presented in graphical form for easy reference.

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LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Concluded)

SYMBOLS, UNUSUAL TERMS AND NON-STANDARD ABBREVIATIONS

C	-	degree Celsius
K	-	degree Kelvin or absolute
kg	-	kilogram
kp	-	kilopond = kilogram force
km	-	kilometer
m	-	meter
mb	-	millibar
mps or m/sec	-	meters per second
T-0 or T-Time	-	missile launch time
n	-	index of refraction
W_{S-N}	-	meridional wind component
W_{W-E}	-	zonal wind component
W_x	-	range direction wind component relative to missile flight path
W_z	-	cross-range wind component relative to missile flight path
T^*	-	virtual temperature
θ^*	-	virtual-potential temperature
GCT or Z	-	Greenwich civil time
Standard	-	refers to the Patrick Air Force Base (PAFB) Reference Annual Atmosphere

ATMOSPHERIC ENVIRONMENT FOR PERSHING MISSILE-405

I. INTRODUCTION

This report presents the more important portions of available atmospheric information pertinent to the missile flight at 2000 EST on 4 March 1963, from Cape Canaveral, Florida. Surface and upper air observations were made as close to missile launch time as possible at the launch site and downrange at Grand Bahama Island and Eleuthera.

Rocket measured winds were determined from radar track of a LOKI II meteorological rocket flight provided by the PAFB Air Weather Service in support of PERSHING Missile-405.

This information is presented to document in detail the atmospheric conditions prevailing at time of missile launch and to provide supporting material for specific atmospheric investigations in connection with missile design and/or missile flight-mechanical performance studies.

II. PRESENTATION AND DISCUSSION OF DATA

A. Source of Data

The general synoptic situation was taken from weather maps made by the U. S. Weather Bureau on missile firing date (Figs. 1, 2, and 3) and from data furnished by the Patrick Air Force Base Weather station.

Surface and upper air observations were made at the Cape Canaveral launch site and downrange stations under the supervision of the U. S. Air Force. These observations were made as close to the missile launch time as possible.

A LOKI II meteorological rocket furnished by the U. S. Air Force was fired in support of Pershing Missile-405.

B. Methods of Computation and Presentation

Wind speed and direction, temperature, pressure, and relative humidity are measured by rawinsondes. Thermodynamic quantities are computed from the rawinsonde data by use of the hydrostatic equation and its modifications as given in the Smithsonian Meteorological Tables (Ref. 1). Thermodynamic values are then determined for each 250 meters of altitude above sea level by interpolation.

Wind data are also interpolated at 250 meter intervals of altitude using the altitude references computed from the hydrostatic equation. Rawinsonde wind data are considered unreliable at high altitudes and low elevation angles (less than 10°). Wind shears are computed for each 250 meter interval of altitude from the rawinsonde data.

The meteorological rocket winds were determined by the method described by Gray (Ref. 2).

Temperatures are fitted by logarithmic interpolation between the ceiling of the rawinsonde temperature curve and the ARDC temperature curve of 9.5C (282.66K) at the 1 mb pressure height. Tabulated ARDC temperatures are used above the 1 mb pressure level and density is computed as before.

The index of refraction is computed by use of the formula given in "Analysis of Refractive Index Errors", by Epstein (Ref. 3).

The rawinsonde measured atmospheric parameters are compared to the Patrick Air Force Base Reference Atmosphere (Ref. 4), by subtracting the reference atmosphere values from the rawinsonde values at corresponding altitudes.

C. General Synoptic Situation

1. Pressure Distribution and Frontal Systems

The surface weather map, at 1800Z on 4 March, showed a high pressure cell in the Atlantic Ocean near 35N 65W. A ridge extended southwestward from this cell across Florida into the Gulf of Mexico. Barometric pressure was relatively high over Florida and the downrange area. At 0100Z on 5 March, the pressure was 1022.4 mb at PAFB. At the same time it was 1023.4 mb at GBI and 1022.8 mb at Eleuthera. A stationary front extended from near Washington, D. C. southwestward to a low pressure center in southeastern Missouri thence southwestward as a cold front through central Texas. Scattered altocumulus clouds were over the Cape, and broken altocumulus with lower scattered cumulus clouds were reported at GBI. It was clear at Eleuthera. Surface winds were southeasterly 4 to 5 mps at the Cape, eastsoutheast 4 to 6 mps at GBI, and easterly with gusts to 13 mps at Eleuthera.

The upper air chart for the 500 mb pressure level showed a high pressure area over south Florida and Cuba with westsouthwesterly wind flow. A deep trough was over Colorado, New Mexico, and Arizona.

D. Surface Weather Observations

This information is given on page 3.

SURFACE WEATHER OBSERVATIONS

Location	Time		Date	Temperature	Relative humidity	Pressure	Wind		Clouds and Weather
	GCT	Missile	1963	°C	%	mb	Direction	Speed	
Cape	0058	-0002	5 March	20.0	91	1022.4	SE	5.1	1 AC
GBI	0100	0000	5 March	22.2	83	1023.4	ESE	5.7	2 CU 9 AC
Eleuthera	0100	0000	5 March	22.8	78	1022.8	E	9.8 + 12.9	Clear

SCHEDULE OF UPPER AIR OBSERVATIONS

Location	Starting Time		Date	Duration of obs	Maximum Wind			Maximum altitude
	GCT	Missile	1963	min	Direction	Speed mps	Altitude km	km
Cape (Rawinsonde)	0124	0024	5 March	117.5	WNW	34	14.5	29.75
GBI (Rawinsonde)	2348	-0112	4 March	114.5	NW	31	13.0	33.0
Eleuthera (Rawinsonde)	0100	0000	5 March	122.5	NW	26	12.75 & 13.0	34.5
Cape (LOKI II Meteorological Rocket)	0200	0100	5 March	13.0	WSW	60	56	56.5

E. Upper Air Observations

1. Schedule of Upper Air Observations

This information is given on page 4.

2. Wind Data

Winds at Cape Canaveral were southeasterly at the surface and started veering just above the surface to become westsouthwesterly by 5 km altitude. From 5 km to 20 km altitude winds were west to westnorthwest and were light and variable above 20 km altitude. The maximum speed was 34 m/sec from the westnorthwest at 14.5 km altitude (Figs. 4 and 5).

Winds at GBI were eastsoutheast at the surface and veered with altitude to become westerly by 5 km. Eleuthera had an easterly surface wind. At 3.5 km the wind at Eleuthera had backed to northeasterly, but veered to westnorthwesterly by 5 km. Above 5 km winds at both GBI and Eleuthera were similar in direction to those at the Cape. The maximum wind speed was 31 m/sec from the northwest at GBI, and was 26 m/sec from the northwest at Eleuthera.

The range direction and cross-range wind components are shown in Figures 6 and 7. The maximum range direction component at Cape Canaveral was a tailwind of 30 m/sec at 14.5 km altitude. At GBI, the maximum range direction component was a tailwind of 31 m/sec at 13 km altitude, and at Eleuthera was a tailwind of 25 m/sec at 13 km altitude. The maximum cross-range component at the Cape was a wind from the right of 17 m/sec at 9 km altitude. Maximum cross-range component at GBI was 11 m/sec from the right at 8.75 km, and was 11 m/sec from the left at 27.75 km at Eleuthera.

Rawinsonde measured wind shears for the Cape, GBI and Eleuthera are shown in Figure 8.

The time and space relations between the missile track and launch site rawinsonde are shown in Figure 9.

Wind data computed from radar data for the meteorological rocket flight are shown in Figures 10 and 11. The maximum reliable wind speed was 60 m/sec from the westsouthwest at 56 km altitude.

3. Thermodynamic Quantities

Rawinsonde measured ambient temperatures for Cape Canaveral and downrange at GBI and Eleuthera are shown in Figure 12. Relative deviations of temperature, pressure, and density from the PAFB reference annual atmosphere are shown in Figure 13. The launch

site and downrange temperatures showed less than 2 percent departure from normal from the surface to 15 km. Above 15 km, temperatures at the Cape and at both the downrange stations decreased to reach the greatest departure from standard between 17 km and 19 km altitude. At the Cape, the greatest temperature deviation was 4.4 percent below standard at 17.25 km. Greatest deviation at GBI was 4.6 percent below standard at 18 km, and was 5.7 percent below standard at 18 km altitude for Eleuthera.

Pressure at the Cape and at both the downrange stations was above standard from the surface through 16 km altitude. The pressure then decreased and was below standard from 19 km altitude to termination of data. Maximum pressure deviation was at Eleuthera where it was 3.3 percent below standard at 30 km altitude.

Density deviations (Fig. 14) at the Cape and the downrange stations were within 2 percent of the standard to 12 km altitude. The density increased above 12 km and maximum deviation for Cape Canaveral occurred at 17.25 km where it was 4.4 percent above standard. Maximum deviation at GBI was 5.4 percent above standard at 18 km and was 6.3 percent above standard at 18 km for Eleuthera.

The relative humidity (Fig. 16) at Cape Canaveral was near standard at the surface where the reading of 87 percent of saturation was the maximum recorded for the sounding. It decreased rapidly from 2 to 2.75 km. From 3 km to 15 km, the relative humidity fluctuated as the instrument ascended through several moist air layers. Relative humidity at GBI and Eleuthera had approximately the same average values as those for the Cape, but more homogeneous moisture distribution caused less variation of relative humidity with altitude.

The index of refraction (Fig. 17) at the Cape and both the downrange stations showed the greatest departure from standard (Fig. 19) between 2 km and 3 km altitude. At the Cape it was $(n-1)10^6 = 24.1$ units below standard at 2.75 km altitude. Maximum departure at GBI was $(n-1)10^6 = 13.4$ units below standard at 3 km altitude and was $(n-1)10^6 = 24.0$ units below standard at 2.5 km altitude at Eleuthera.

III. CONCLUSIONS

Scattered altocumulus clouds were over the Cape area at launch time. Surface winds were southeasterly at 5.1 m/sec. Freezing level was 4300 meters altitude.

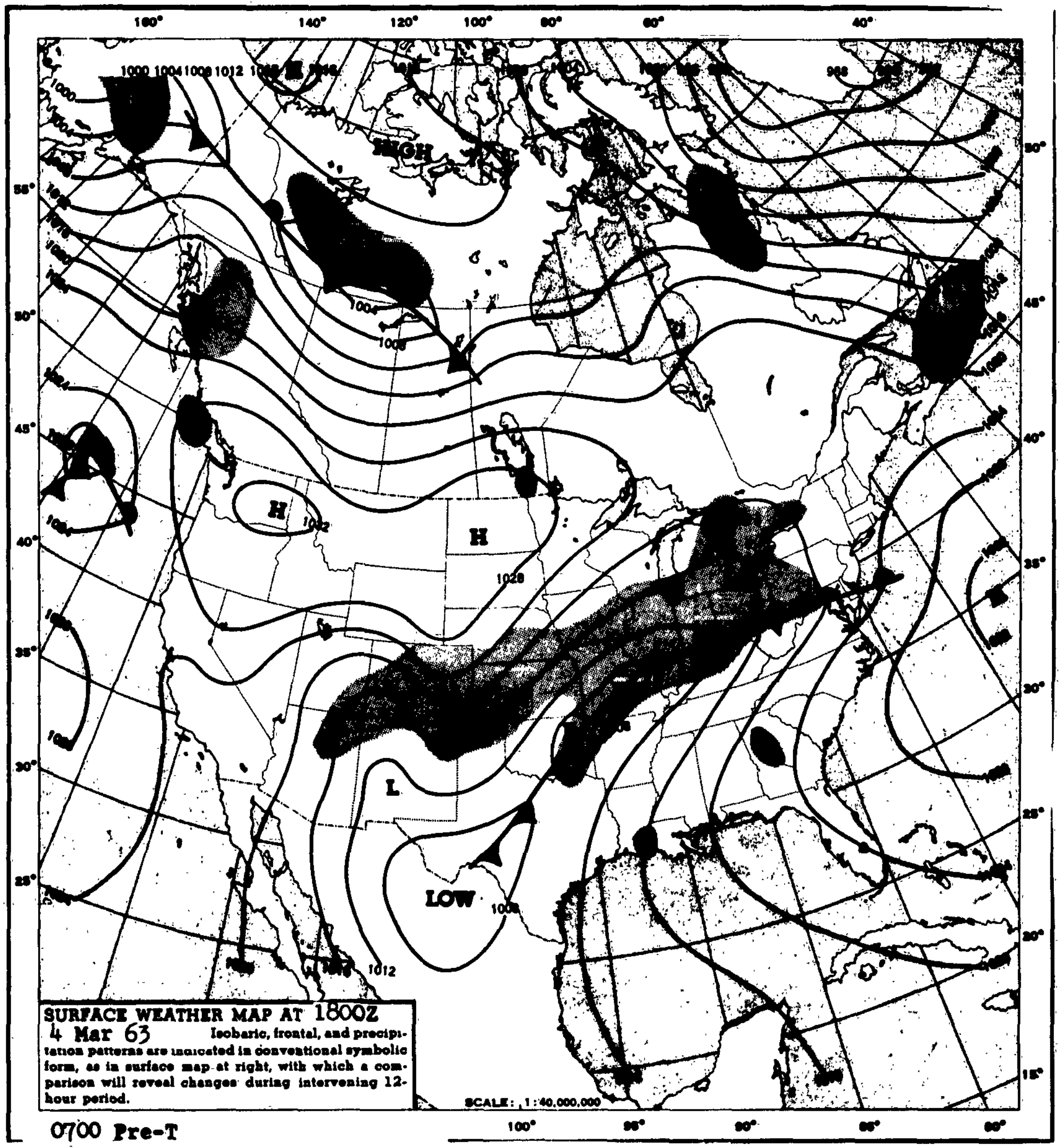

Fig. 1 · SURFACE WEATHER MAP AT 1800Z, 4 MARCH 1963, 0700 PRE-T

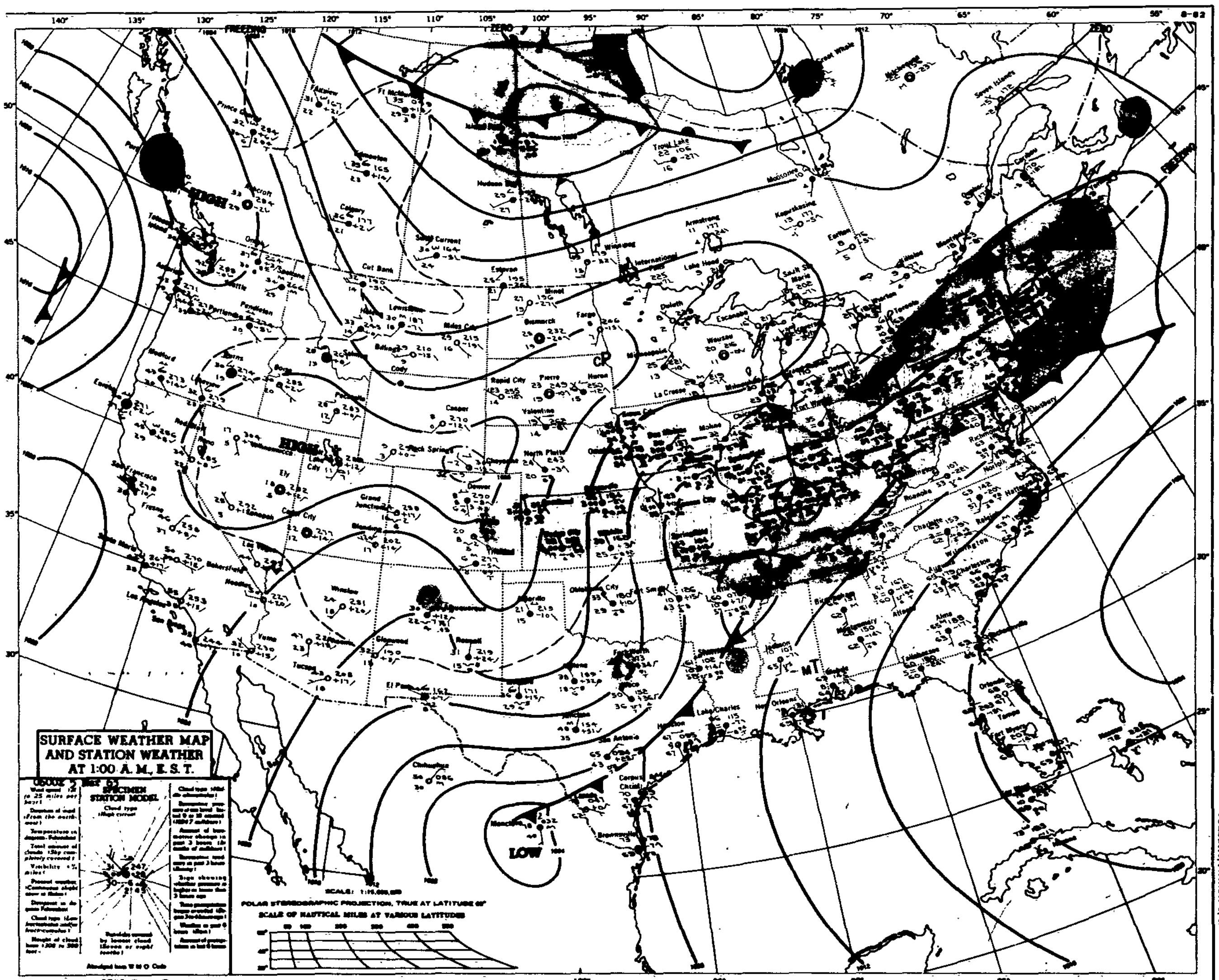

Fig. 2. SURFACE WEATHER MAP AT 0600Z, 5 MARCH 1963, 0500 POST-T

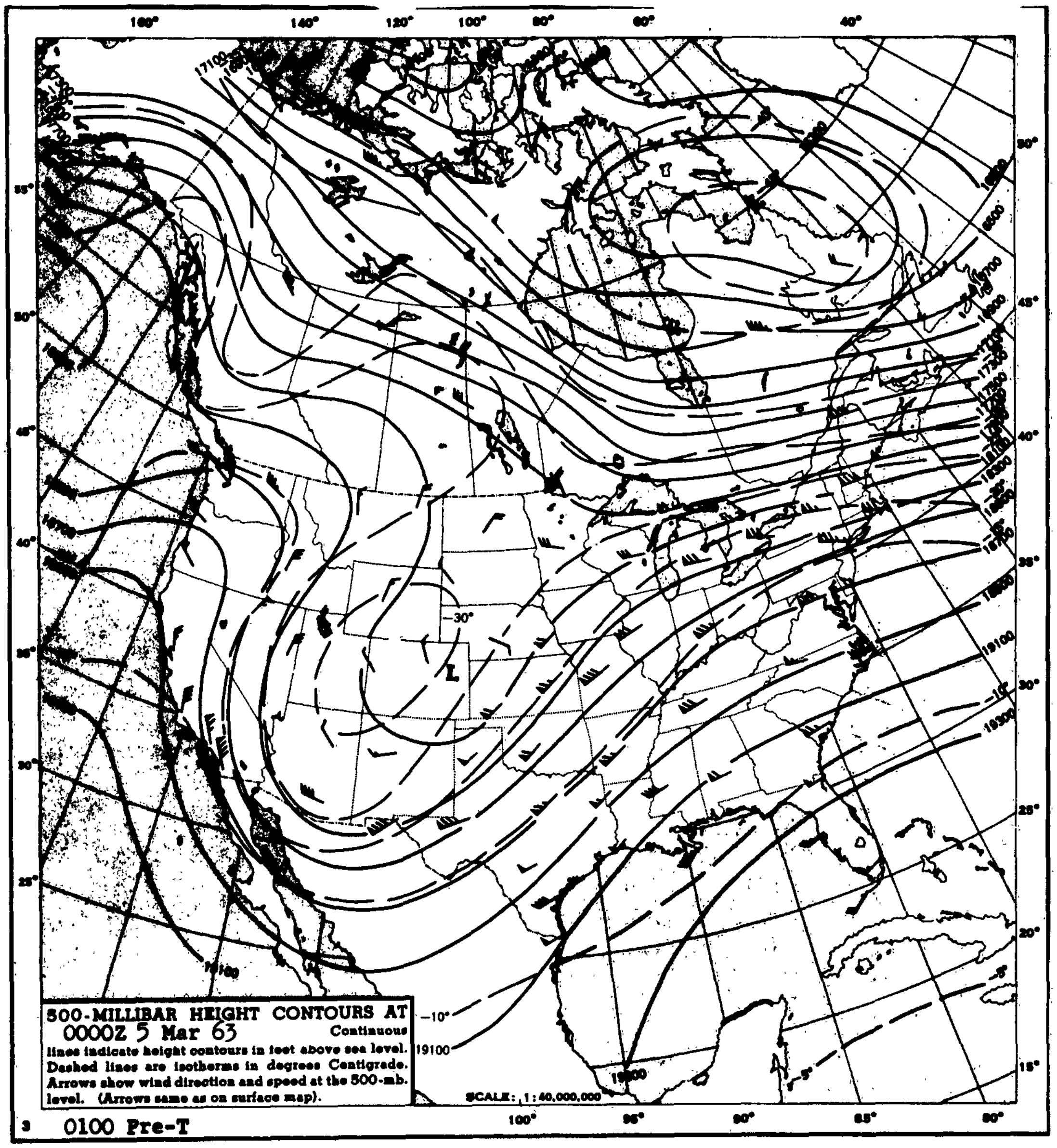

Fig. 3. 5-MILLIBAR HEIGHT MAP AT 0000Z, 5 MARCH 1963, 0100 PRE-T

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No. 3

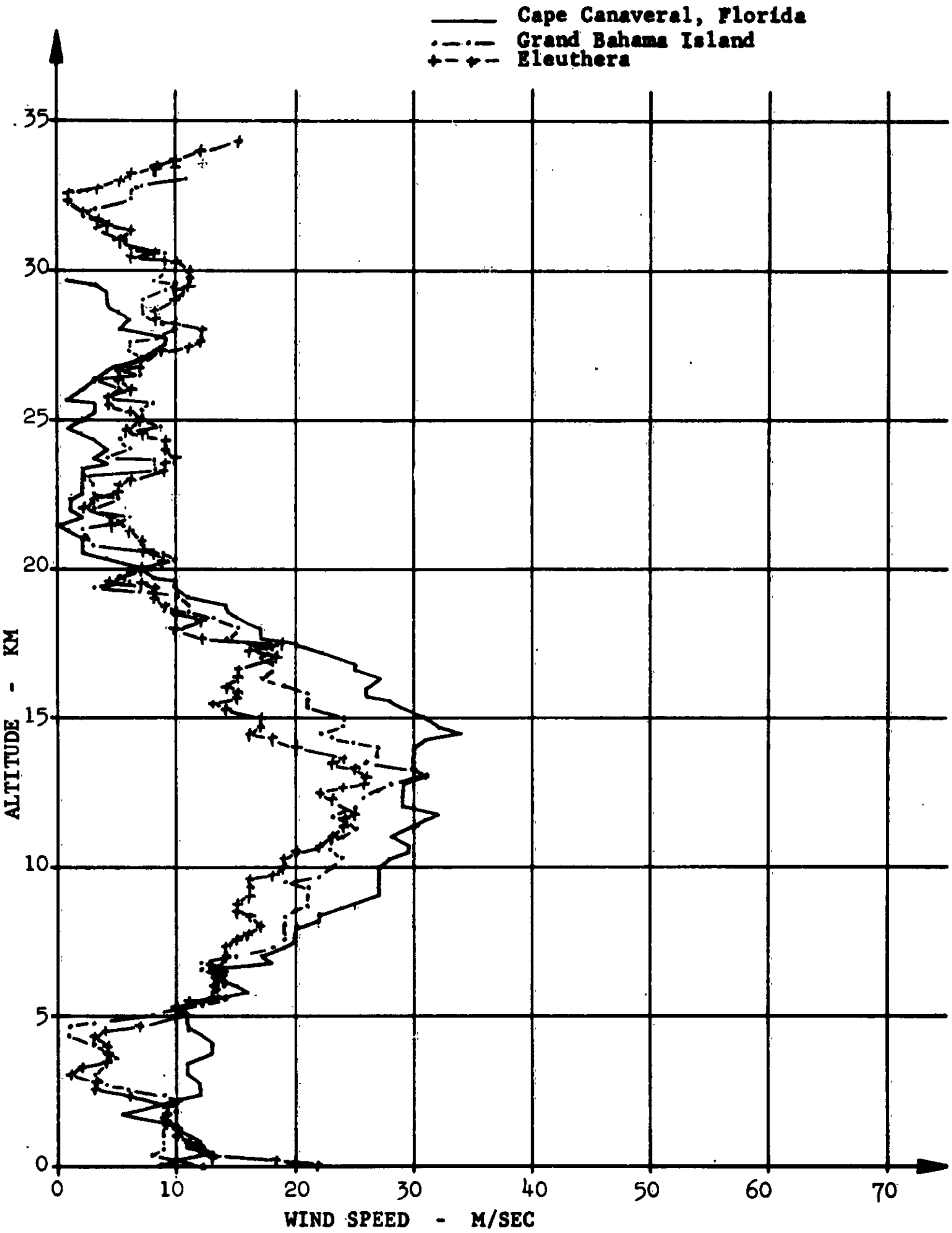
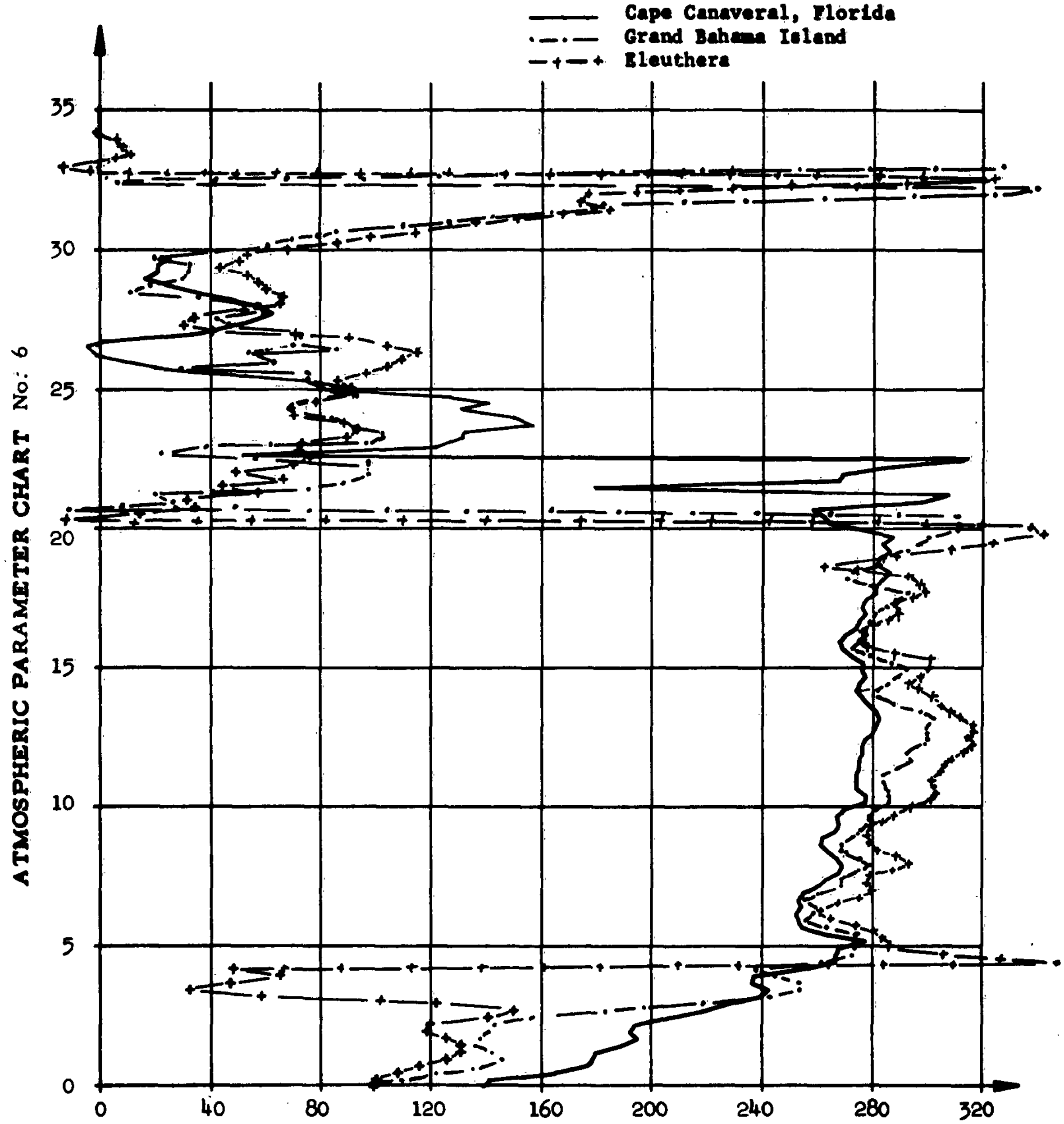


Fig. 4. RAWINSONDE MEASURED WIND SPEED, CAPE CANAVERAL, FLORIDA, GRAND BAHAMA ISLAND, AND ELEUTHERA



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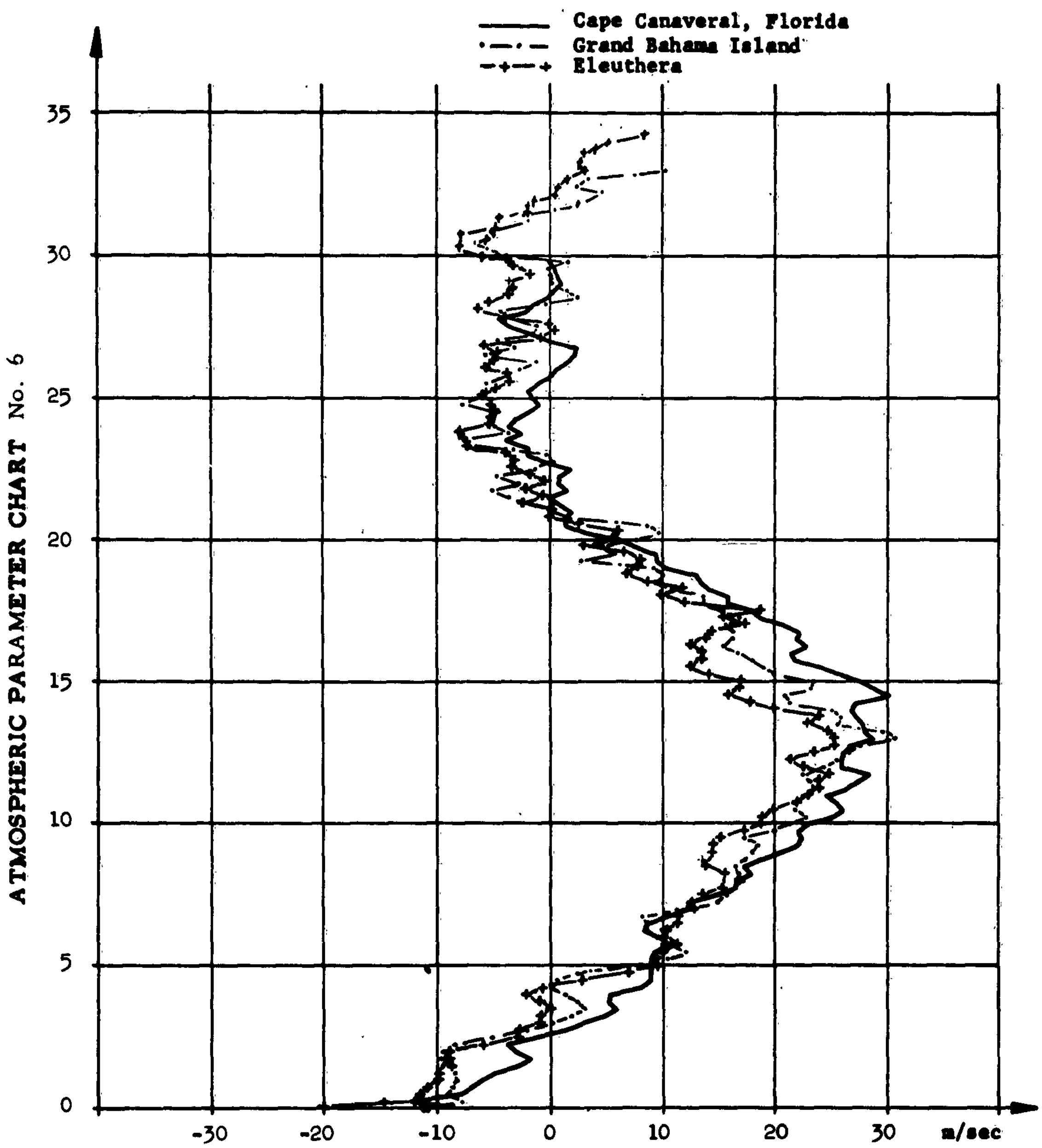

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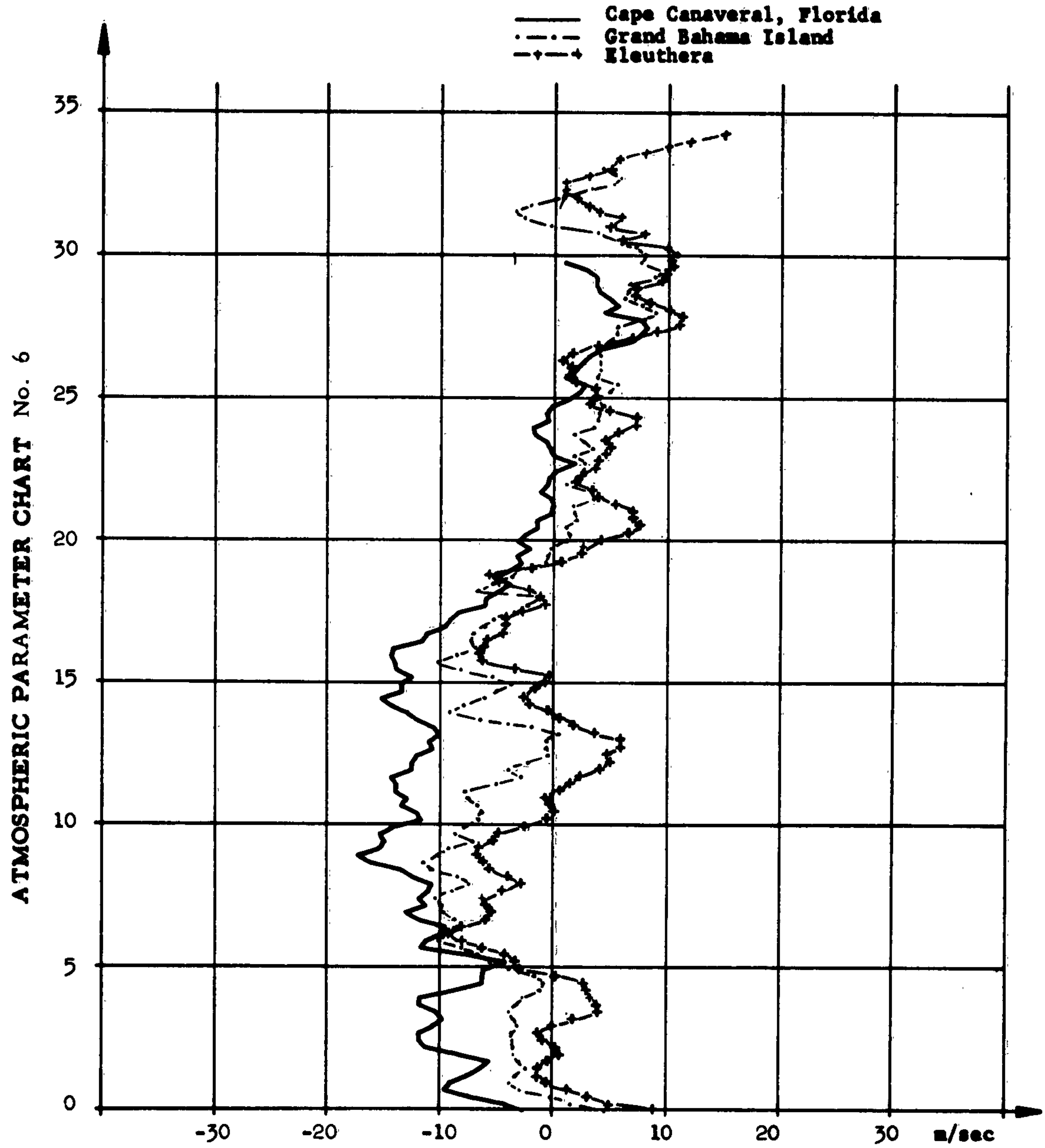

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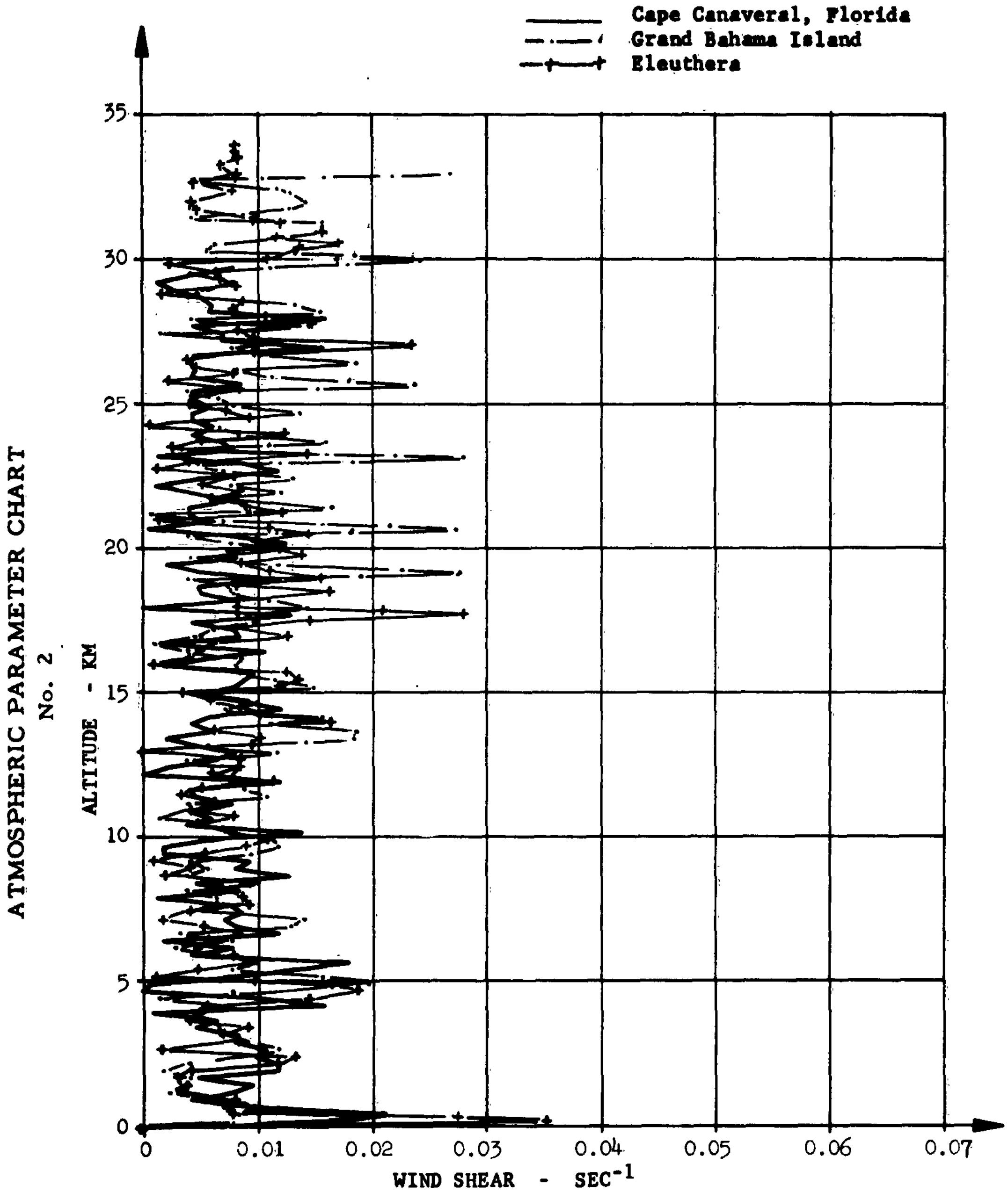

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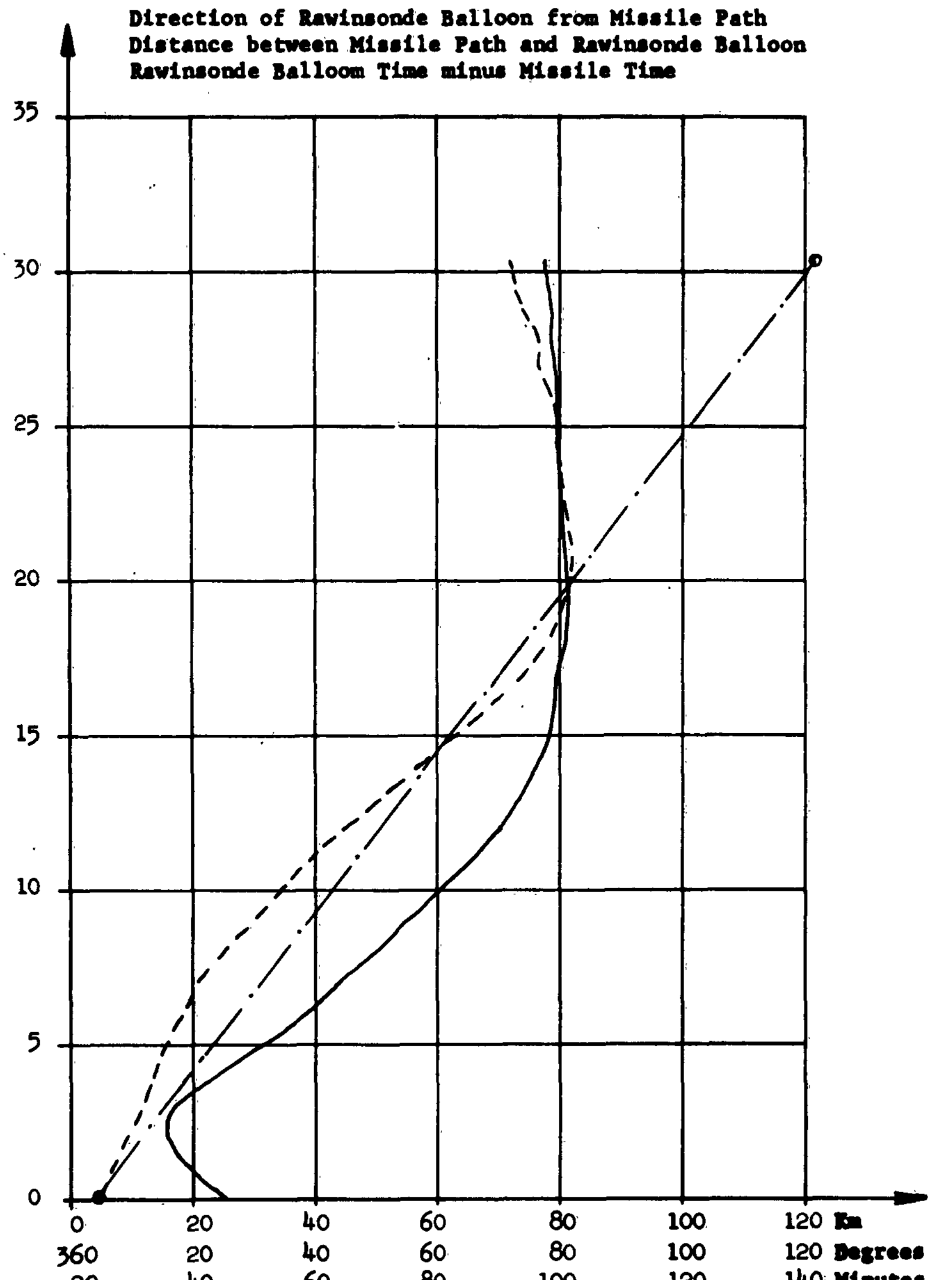

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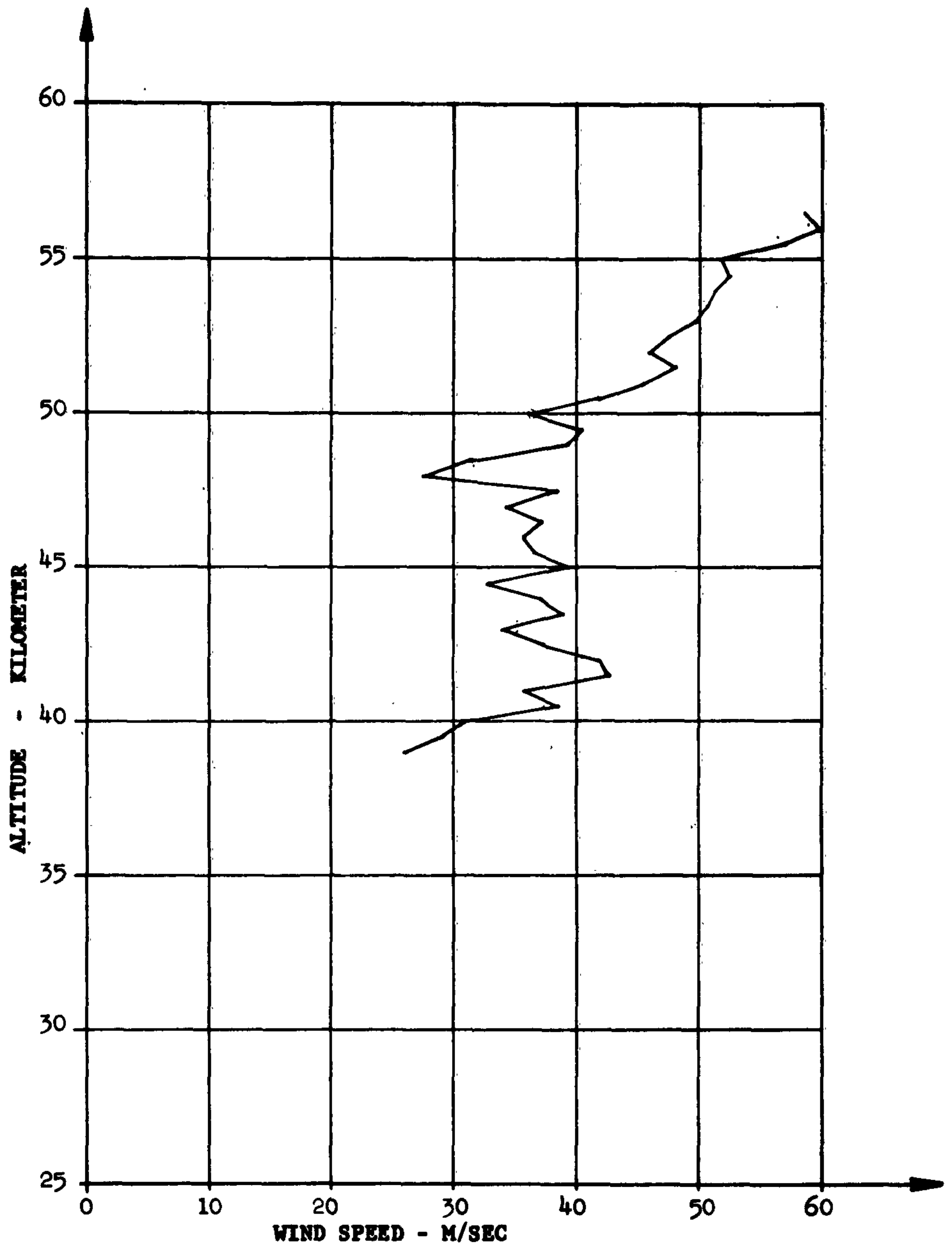

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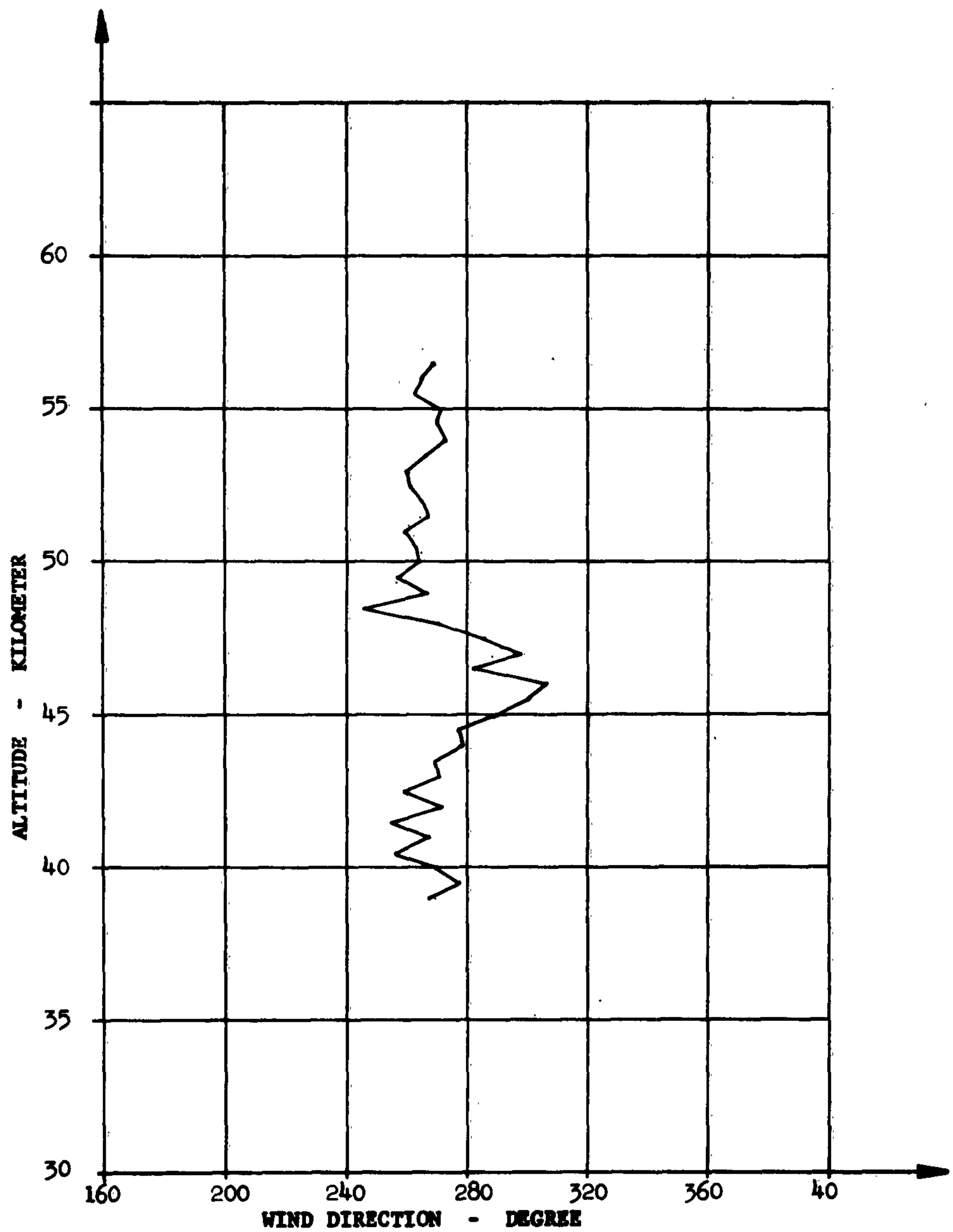

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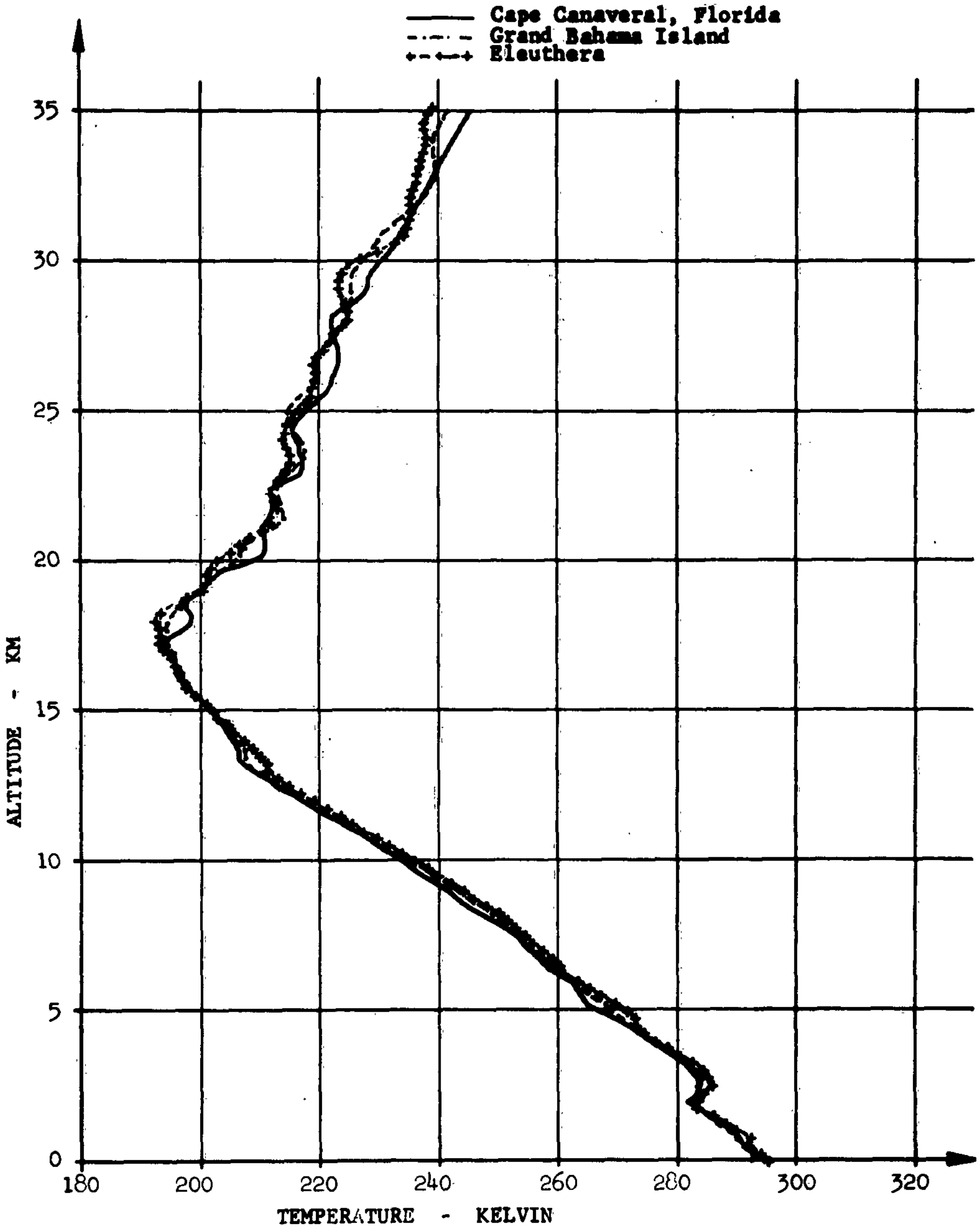
ATMOSPHERIC PARAMETER CHART
No. 1



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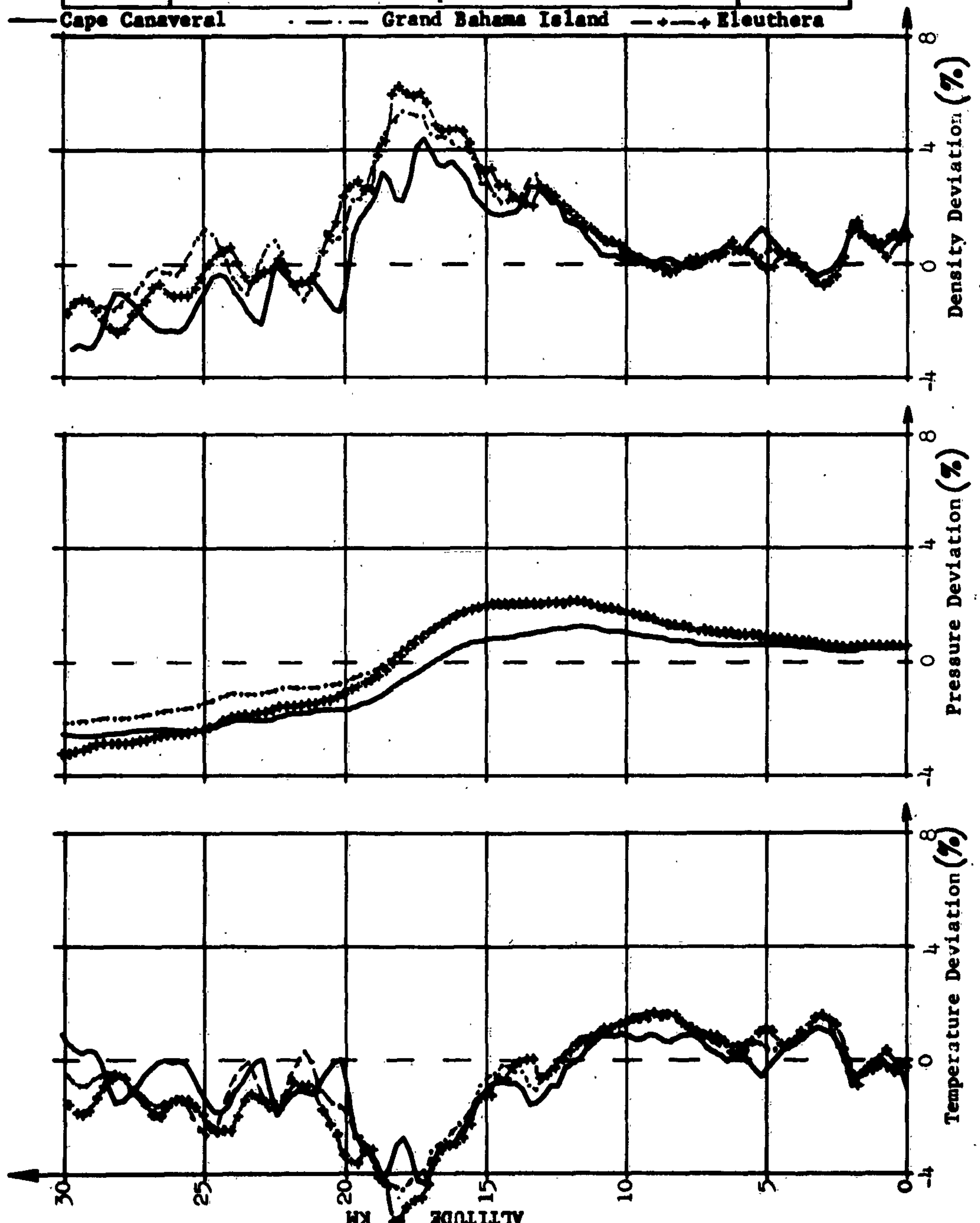

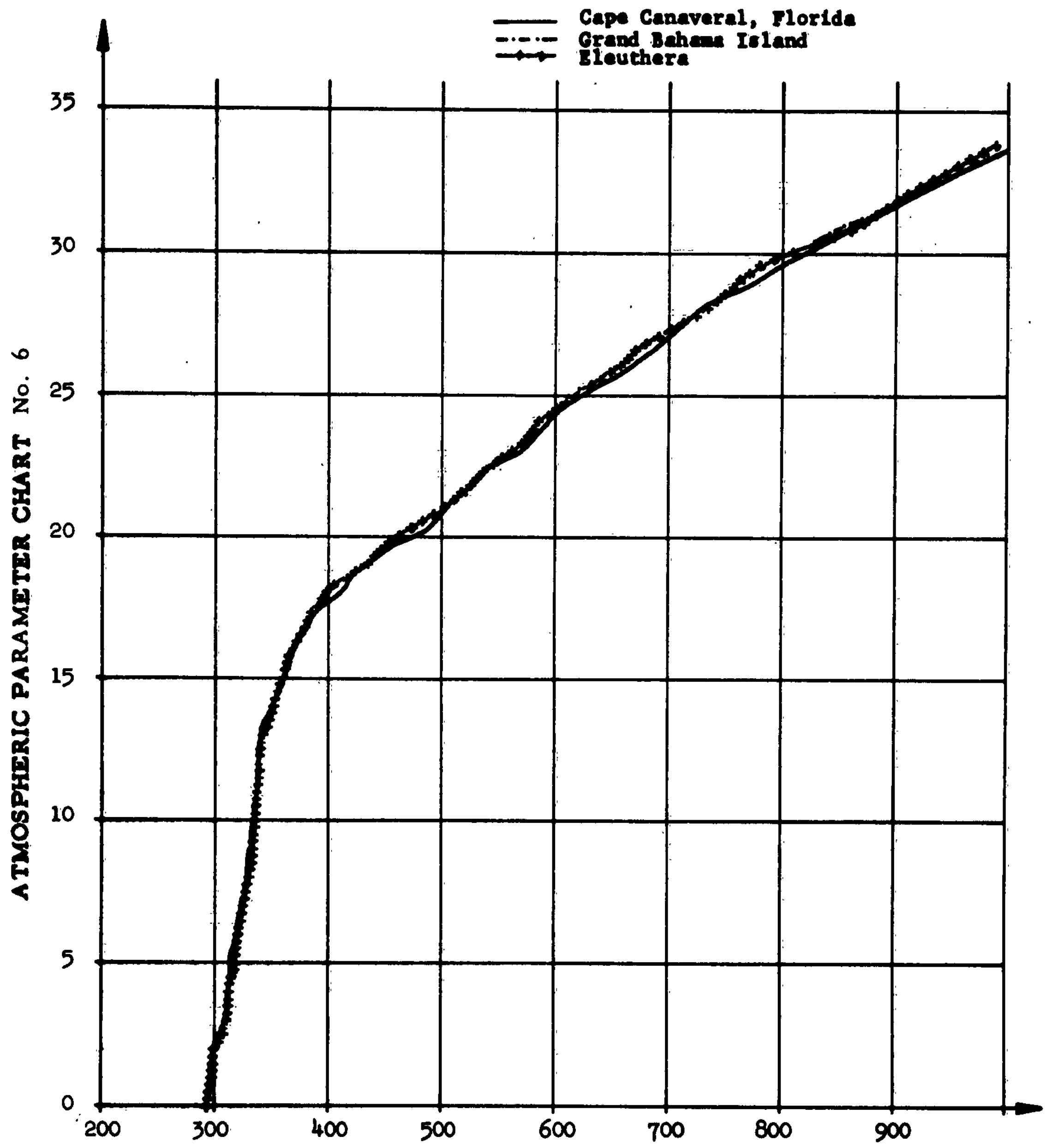

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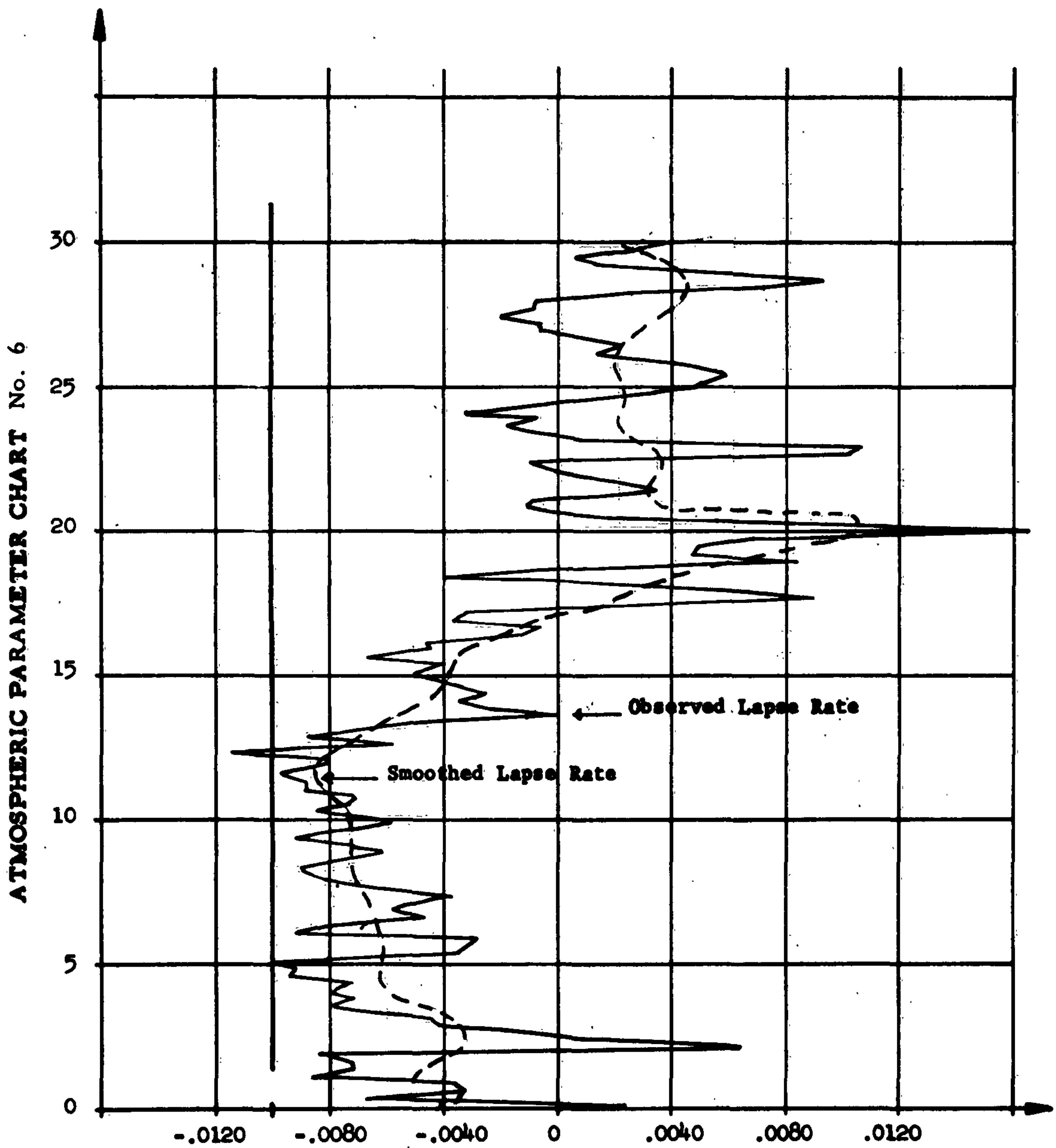

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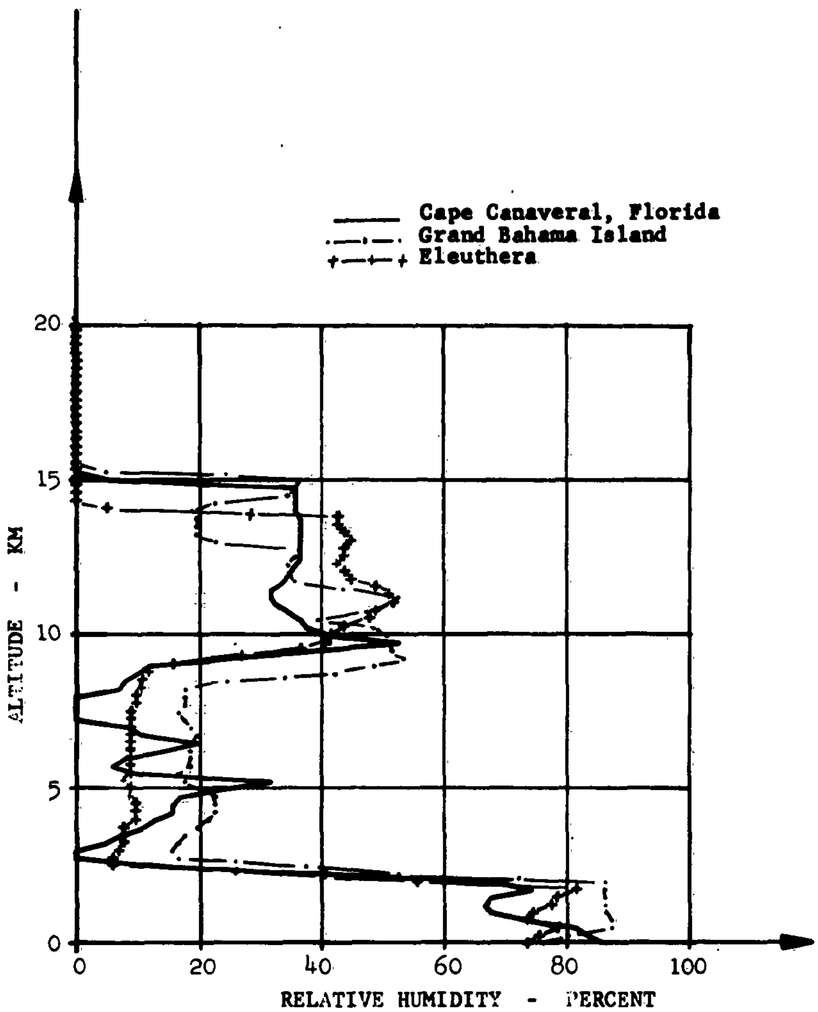

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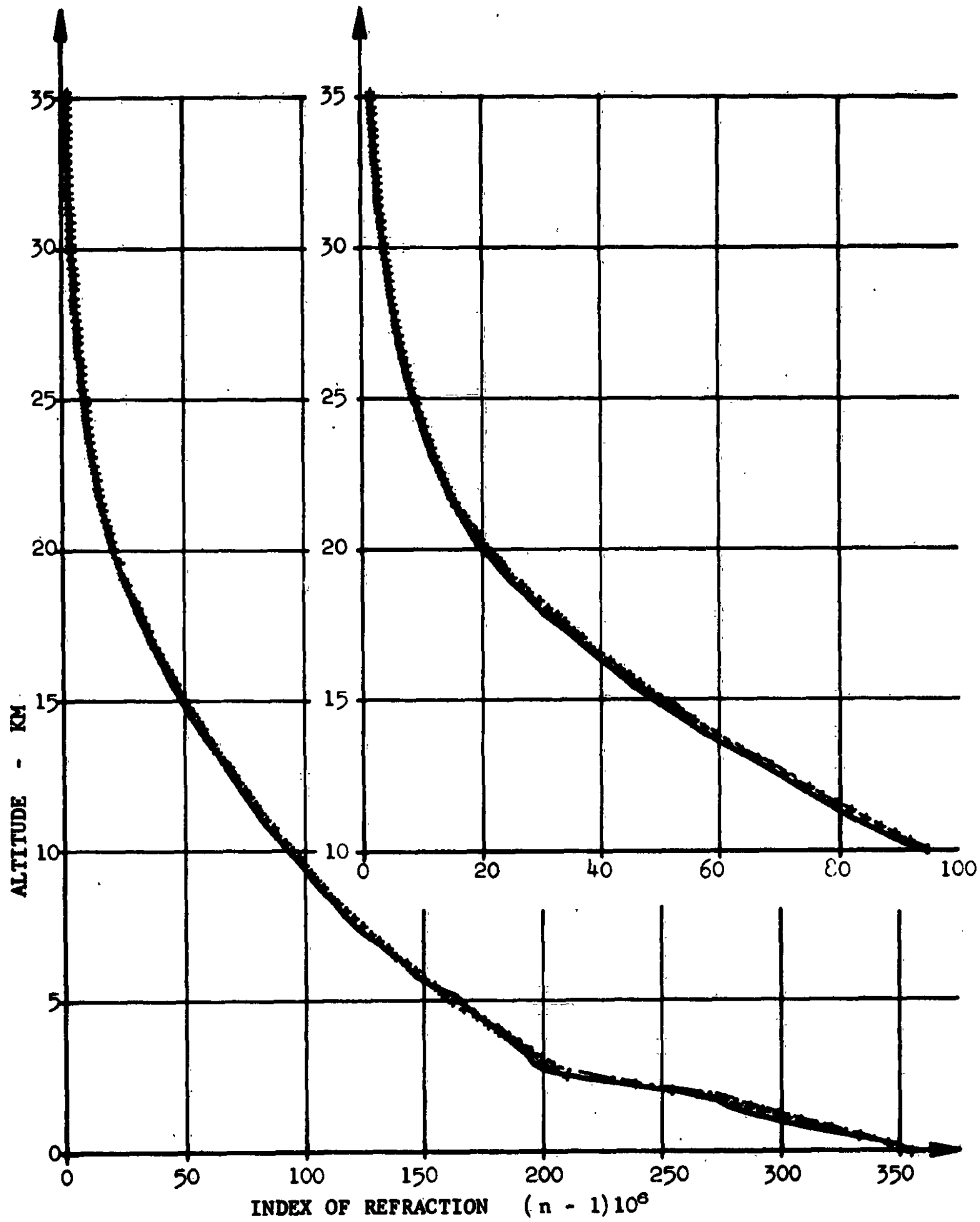

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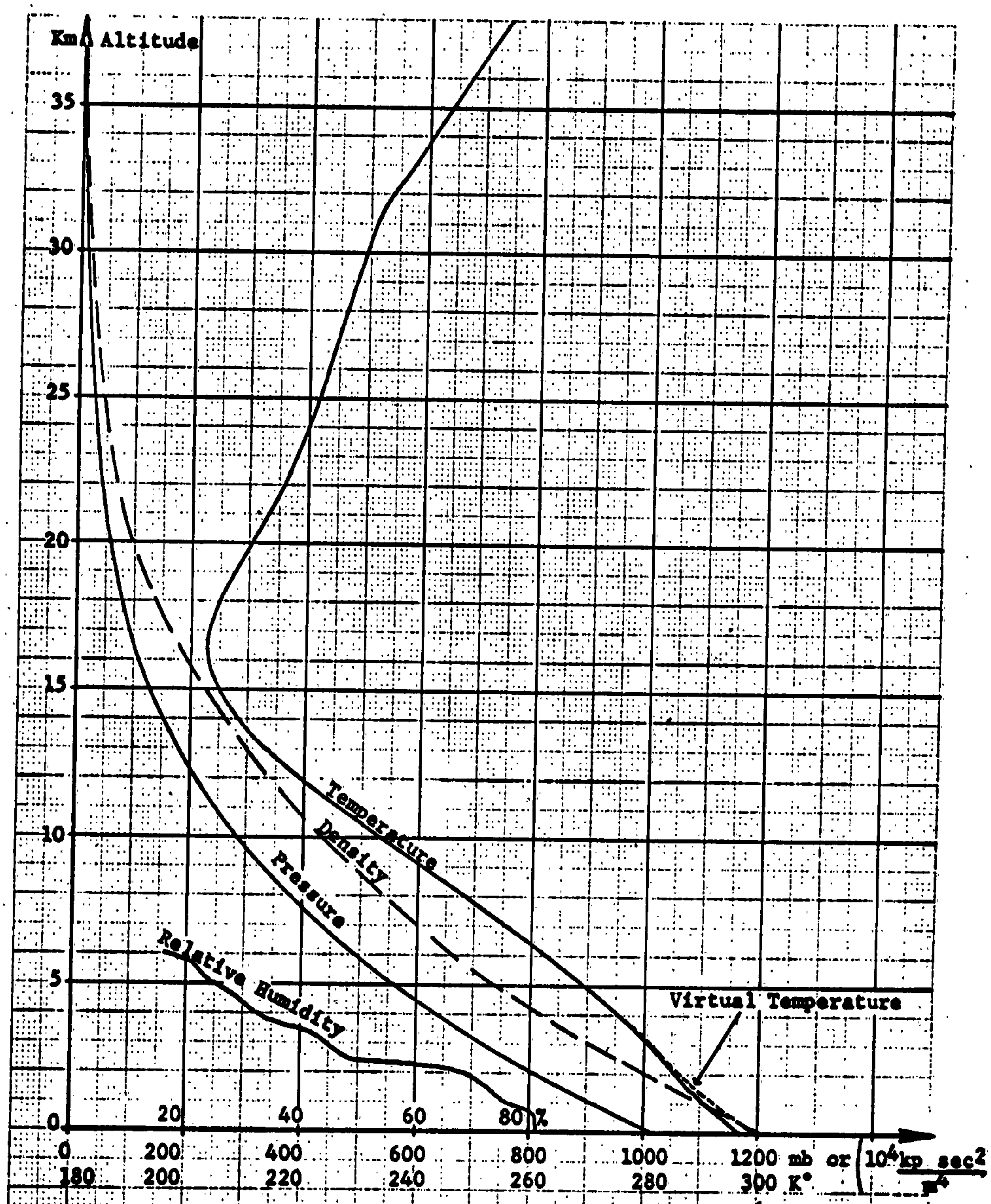

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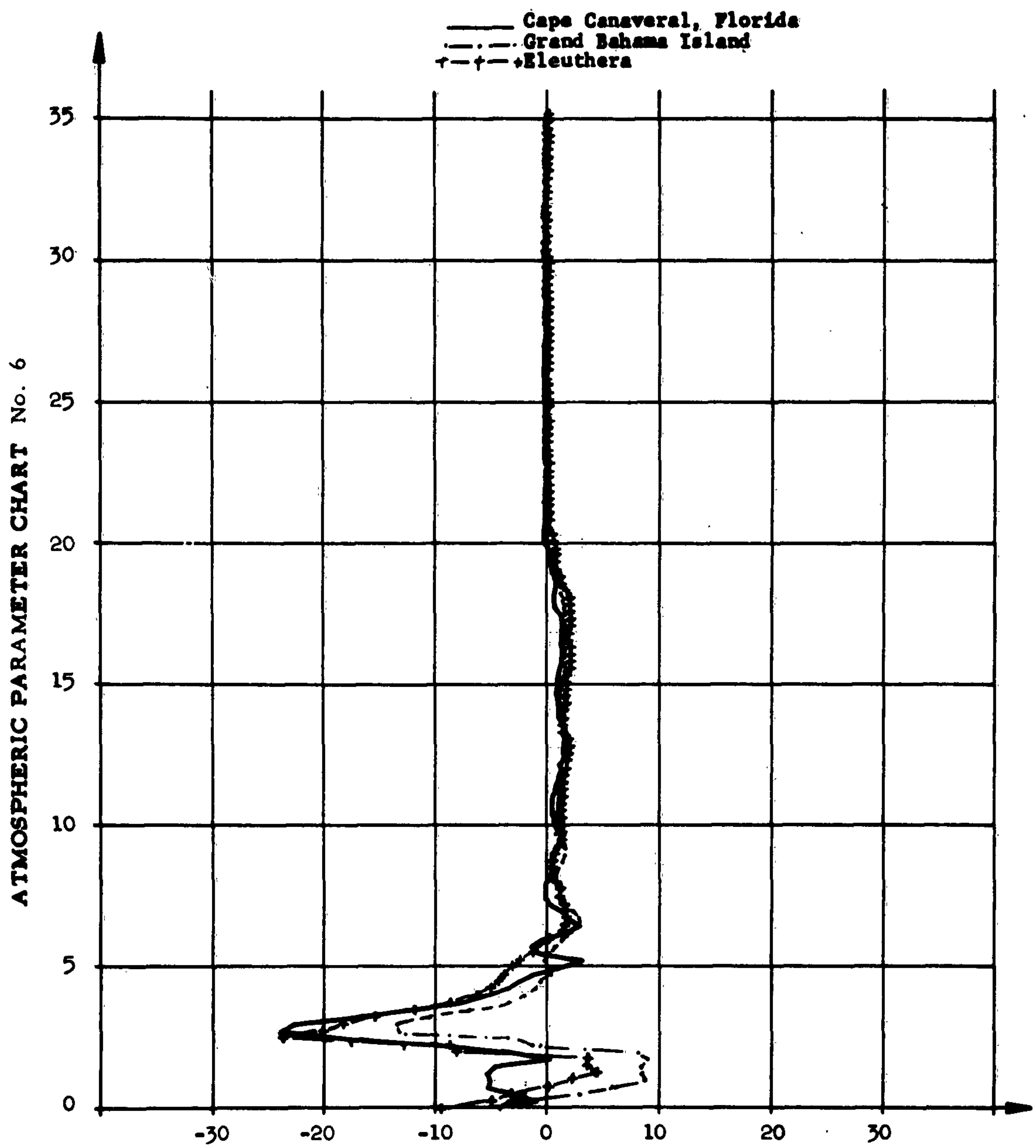

Fig. 19 ABSOLUTE DEVIATION OF THE INDEX OF REFRACTION FROM THE PATRICK AIR FORCE BASE REFERENCE ANNUAL ATMOSPHERE P-405

REFERENCES

1. List, R. J., Smithsonian Meteorological Tables, Sixth Edition, Revised 1951.

2. Gray, Anne, Computation of Wind Flow with Smoothed Input Data From Meteorological Rocket Data, ABMA Report DA-TN-35-60, June 24, 1960.

3. Epstein, R. A., Analysis of Refractive Index Errors, AFTR No. 2, 1951.

4. Smith, O. E., A Reference Atmosphere for Patrick Air Force Base, Florida (Annual), NASA Report TN-D-595, 1960.

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1. Pershing--Atmospheric environment
2. Pershing--Meteorological factors
3. Pershing--Wind effects
4. Pershing 405
5. Rawinsonde data
6. Wind--Measurement

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